TAMDL: Simulation of the water quality of streams affected by AMD.

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Introduction

- The Total Acid Mine Drainage Loading (*TAMDL*) computer program is designed to simulate the evolution of stream water quality for a watershed affected by acidic mine drainage (AMD) and its treatment.
- Program is designed to assist in the development of mining TMDL's.
- Simulated watershed is divided into sub-watersheds which are modeled sequentially.
- Development of *TAMDL* computer program is an on-going task of the NMLRC.

Governing Equation

- *TAMDL* simulates the evolution of stream water quality by solving a finite difference approximation of the governing equation.
- Governing equation is a transient, one-dimensional, hyperbolic, partial differential equation.
- Governing equation includes:
  - Advection Term
  - Dispersion Term
  - Reaction Terms
  - Loading Term

Boundary Conditions

- Temperature and constituent concentrations are specified upstream of model domain.
- Upstream conditions can vary with time.
- Spatial gradients of temperature and concentration are assumed to be zero downstream of the model domain.
- When mean velocity is zero, downstream boundary condition is applied to upstream.

Numerical Algorithm I

- The advection and dispersion terms are solved with the explicit MacCormack predictor-corrector, finite difference method.
- Explicit algorithm chosen because of the hyperbolic nature of these terms.
- MacCormack algorithm selected because of its proven track record, versatility and second order accuracy.
- Size of time step is calculated continuously.

Numerical Algorithm II

- The loading and reaction terms are solved with the familiar fourth order Runge-Kutta method.
- Selection was possible because these terms involve only the constituent concentration and time.
- High order of accuracy permits simulation of conditions with relatively high reaction and loading rates.
- *TAMDL* uses the same time step for all of the terms of the governing equation; too fast kinetic rates can result in mass balance error.

Water Quality Constituents

- Currently *TAMDL* simulates temperature, net acidity, pH, ferrous iron concentration, ferric iron concentration, manganese concentration, total aluminum concentration and dissolved oxygen.
- The pH is calculated with an empirical net acidity – pH relationship.
- Net acidity is treated as a conservative tracer.
- The inverse of this relationship is used to simulate the effects of proton production.

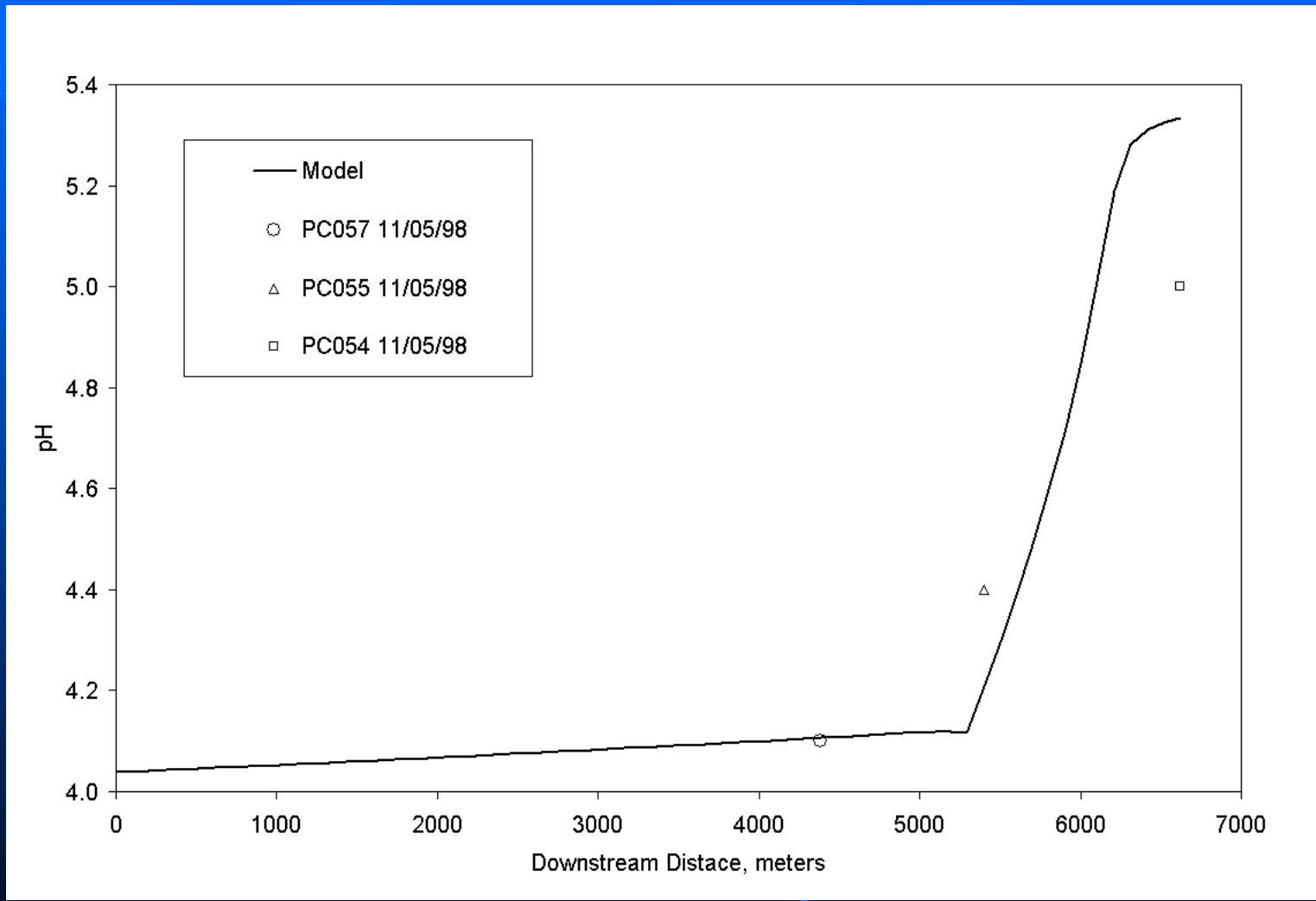
Simulated Processes

- Ferrous iron oxidation.
- Ferric iron sedimentation.
- Manganese oxidation and precipitation.
- Aluminum precipitation.
- Stream aeration (can be switched off).
- Decay of sediment organic materials.
- Meteorological heating.
- Passive AMD treatment with limestone.
- Constituent loading (except for pH).

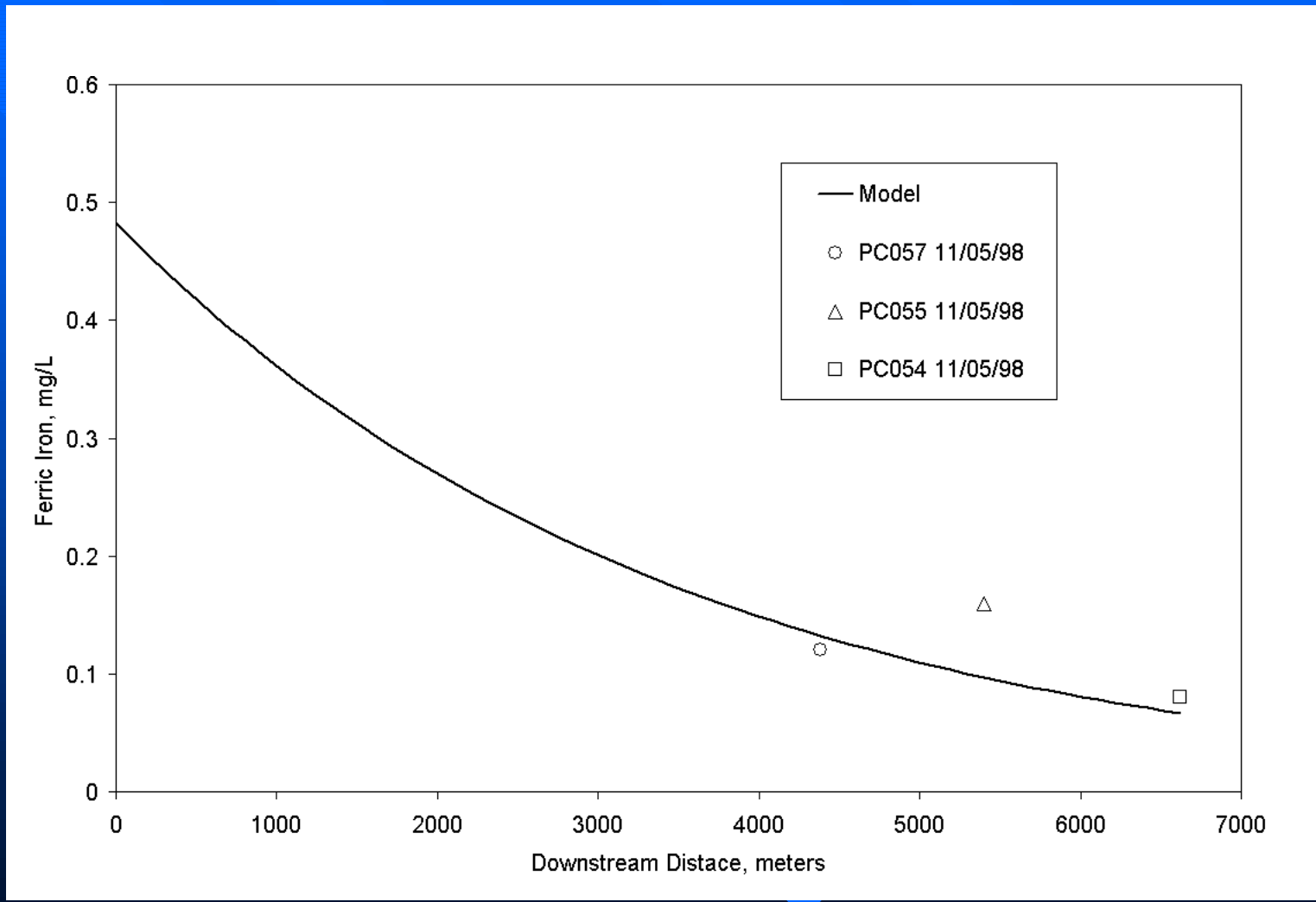
Hydraulics

- Mean flow velocity is included in the advection term and must be uniform within a sub-watershed.
- *TAMDL* assumes normal flow, but could easily be modified to accept the results of a sophisticated hydraulic model.

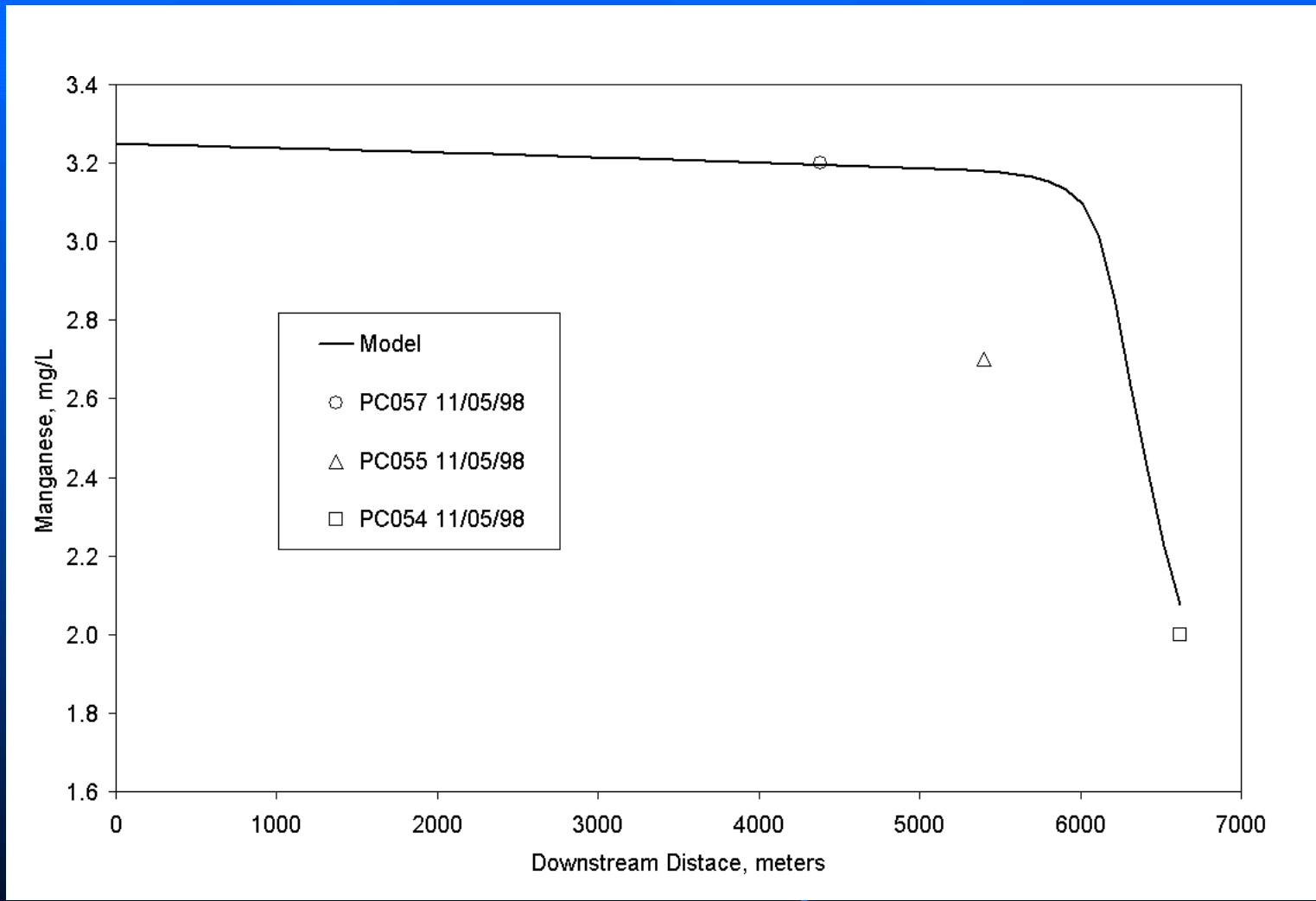
Uncalibrated Results: pH



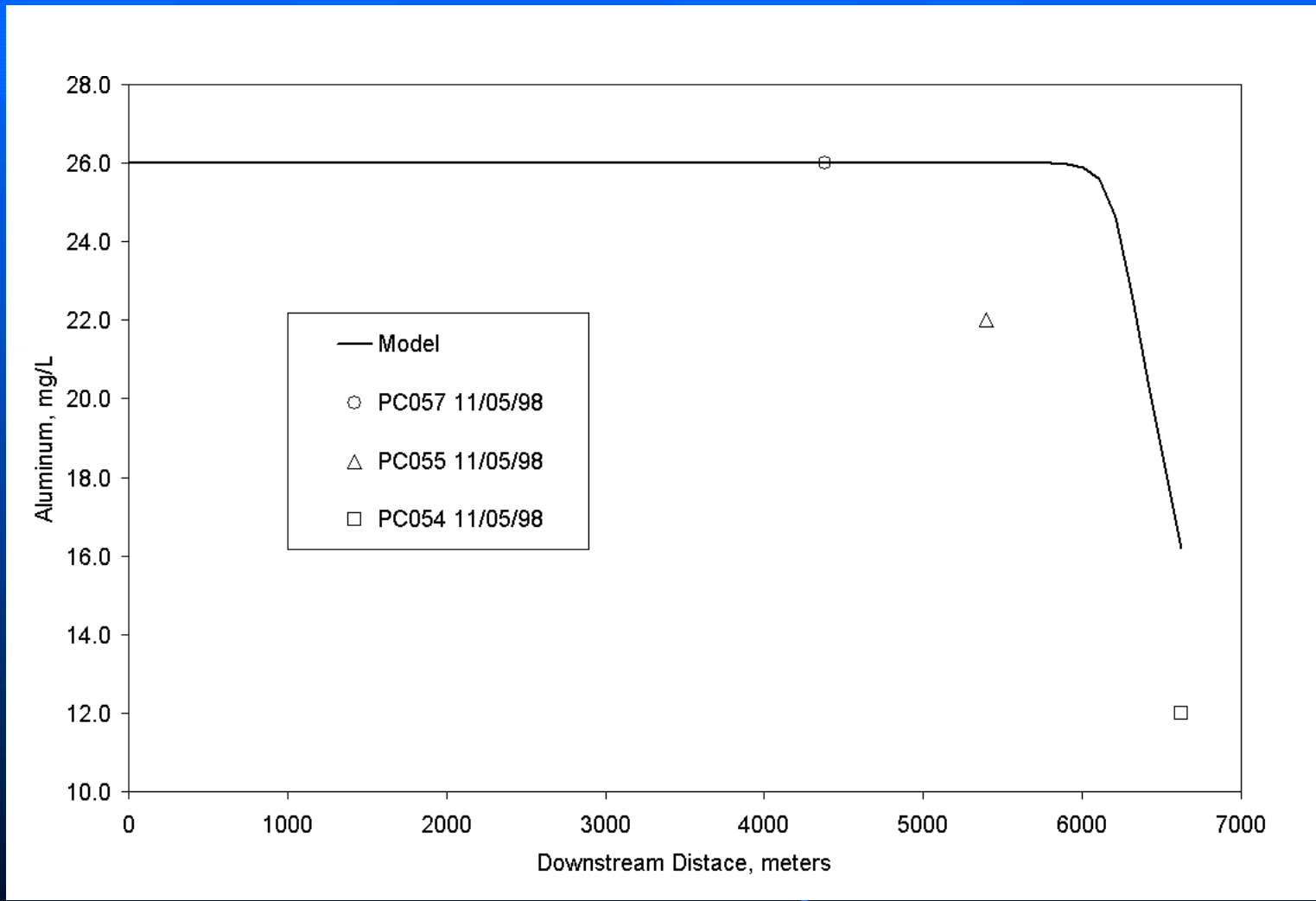
Uncalibrated Results: Total Iron



Uncalibrated Results: Manganese



Uncalibrated Results: Aluminum



Conclusion

- *TAMDL* is a transient, finite difference computer program designed to simulate the evolution of stream water quality in a watershed affected by AMD.
- Because the program's computational domain is restricted to the stream channel, all point and non-point source loading must be explicitly specified.
- At the present time, the computer program simulates those water quality constituents required to perform a mining TMDL study.